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Volume 4

Specifications

November 1976

Part 3
Labcraft Instrument Systems
General Specification

Atmospheric, Magnetospheric and Plasmas in Space (AMPS) Spacelab Payload Definition Study

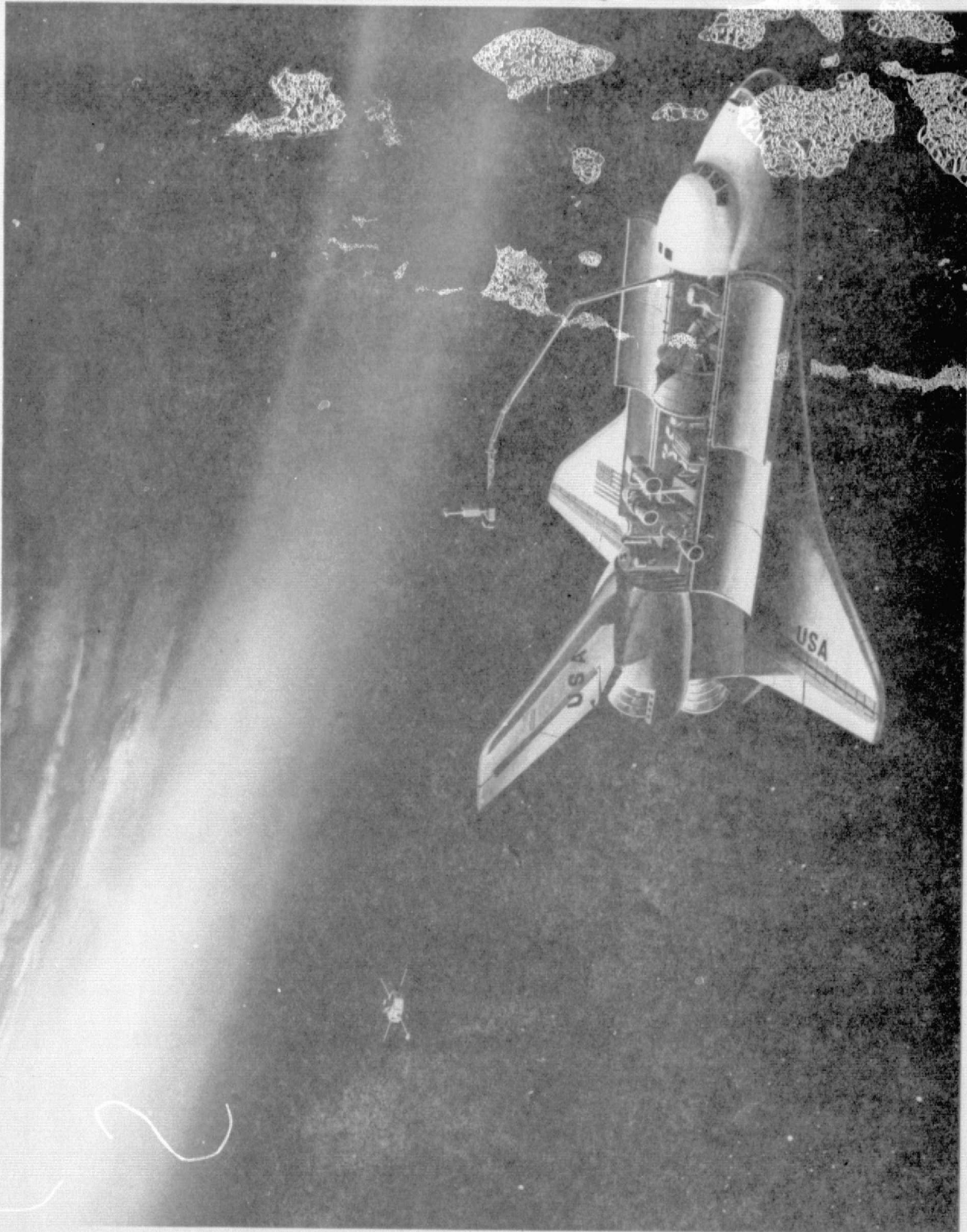
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FOREWORD

The AMPS final report is submitted by Martin Marietta in accordance with Data Procurement Document Number 486, Revision A, of Goddard Space Flight Center Contract NAS8-31689.

The AMPS final report consists of seven volumes. They are:

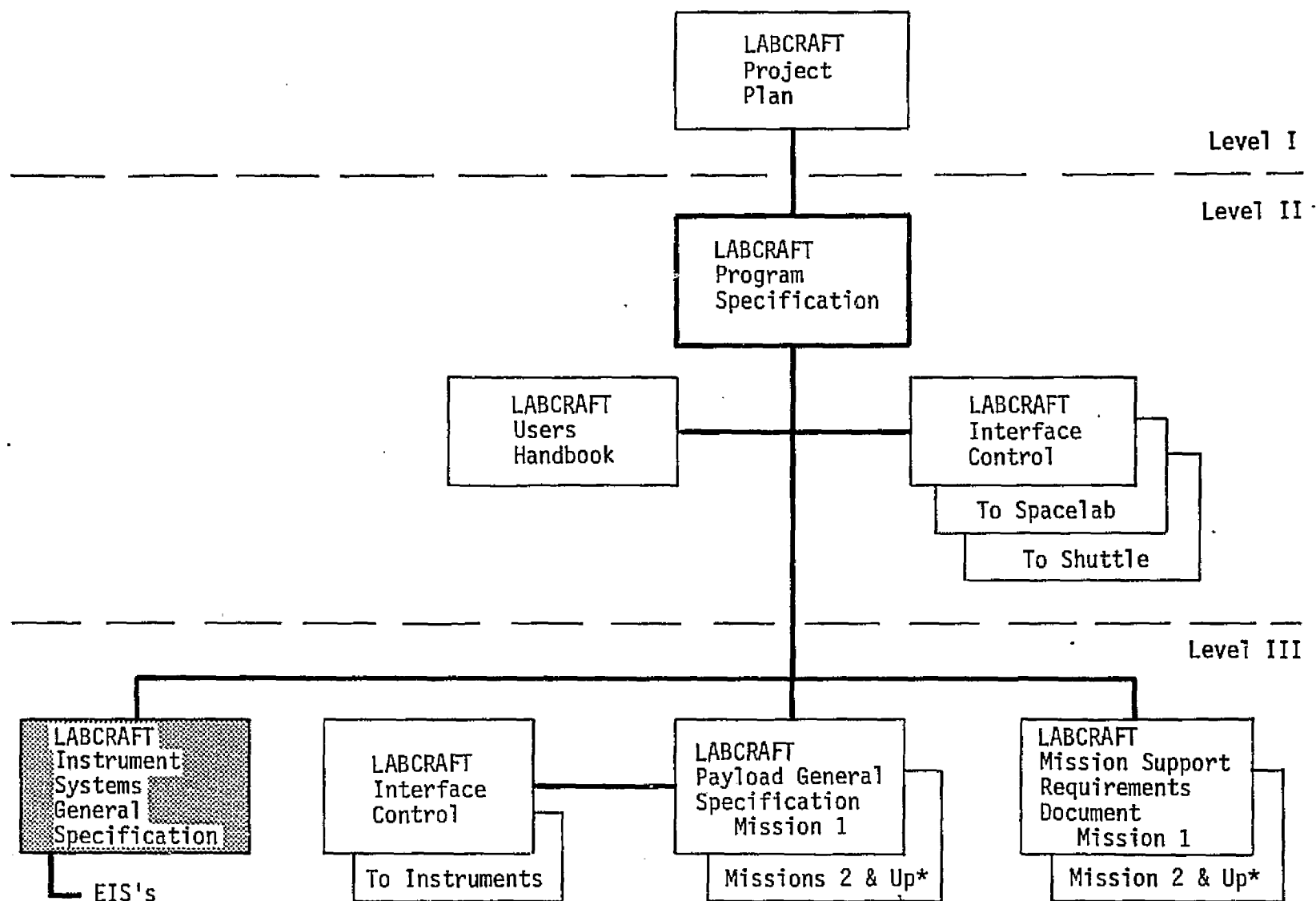
Volume 1	DR MA-05-A	Executive Summary Report
Volume 2	DR SE-01-A	Mission Support Requirements Document
Volume 3	DR SE-02-A	Interface Control Documents
	Part 1	AMPS Payload to Shuttle ICD
	Part 2	AMPS Payload to Spacelab ICD
	Part 3	AMPS Payload to Instruments ICD
Volume 4	DR SE-03-A	Specifications
	Part 1	AMPS Program Specification
	Part 2	Labcraft Payload General Specification
	Part 3	Labcraft Instrument Systems General Specification
Volume 5	DR SE-04-A	Deleted per Paragraph I, Attachment A, Request for Proposal under Changes Clause, dated 8/31/76
Volume 6	DR SE-05-A	Instruments Functional Requirements Document
Volume 7	DR MA-04-A	Program Analysis and Planning for Phase C/D Document
Volume 8	DR NF 003R-A	Program Study Cost Estimates Document

PREFACE

This Instrument Systems General Specification provides guidelines and general requirements applicable to the development of instrument flight hardware intended for use on the GSFC Shuttle Scientific Payloads Program. The objective is to provide criteria, guidelines and an organized approach to specifying the appropriate level of requirements for each instrument in order to permit its development at minimum cost while still assuring crew safety.

It is recognized that the instruments for these payloads will encompass wide ranges of complexity, cost, development risk, and safety hazards. This document provides the flexibility required to adapt the controls, documentation and verification requirements in accord with the specific instrument.

The relationship of this document to other Program Requirements Documents is shown in the diagram on the facing page.



* Reissue or Addenda, depending on magnitude of change.

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1. SCOPE AND APPLICATION

The application of this document to the program will begin at the stage where a preliminary selection of the investigations to be performed on a specific flight has been completed by NASA Headquarters, the Principal Investigators (PI's) or PI teams have been designated, and the instrument requirements identified at a concept level.

The next stage in the development of a flight payload is the detailed definition of the implementation requirements for the proposed investigations. This includes the experiment operation requirements and the instrument requirements for each of the selected investigations. The experiment operation requirements definition will be controlled by the "Mission Support Requirements Document." The instrument requirements definition and subsequent instrument development activities are the subject area for this document.

The responsible organizations involved are:

- a. The GSFC Project Office which is responsible for directing and coordinating the overall definition, development, and integration activities. The Project Office will generate a "Statement of Work" for the specific instrument development requirements.
- b. The Principal Investigator (or PI team) who is responsible for the definition of the instrument performance requirements. These requirements will be contained in Part I of the instrument "End Item Specification."

- c. The Instrument Developer who may or may not be the PI. - who is responsible for Part II of the "End Item Specification" which details the instrument configuration and verification plan.
- d. The Payload Prime Contractor who is responsible for the instrument "Interface Control Document" and for compatibility analyses of the instrument to the payload.

The responsibilities of these organizational entities will require intensive interaction during the definition and development phases in order to produce an effective and safe flight payload at minimum cost. A more detailed discussion of the program documents identified above is given in the following paragraphs.

1.1 STATEMENT OF WORK

Based on the selected investigation proposal as submitted by the PI, the GSFC Project Office will generate a preliminary Statement of Work (SOW) defining the tasks required to develop the specific instrument(s) required to carry out the investigation. This SOW will provide an initial judgment of the appropriate criticality ranking of the specific instrument and the consequent levels of programmatic controls and product verification requirements. The objective is to adapt the development planning and controls imposed to the simplest level consistent with the safety hazards, estimated costs and the degree of development required for the specific instrument. The "Criticality

Category" ranking levels are explicitly defined in paragraph 3.1. The SOW will follow the guidelines given in NHB 5600.2, Statements of Work Handbook, Chapter 3 - "Statements of Work for Definition and Development of Major System." It will reference but not duplicate the information contained in the instrument EIS-Part I and the instrument ICD, both of which are under concurrent development by, respectively, the PI and the payload prime contractor. The preliminary SOW, along with the EIS-Part I and the preliminary ICD, are to be reviewed at the Preliminary Requirements Review (PRR). After the SOW has passed this milestone review it will become the basis for negotiation of the instrument development task.

The SOW will address the areas listed below:

- a. Management plans required.
- b. Number of deliverable items of flight hardware.
- c. Number of deliverable items of ground support equipment.
- d. Specify verification approach to be used. Including planned division of test operations between the Instrument Developer and the GSFC Instrument Certification facility.
- e. Logistics support requirements including spares.
- f. Configuration management and control requirements.
- g. Formal design reviews.
- h. Data and documentation requirements.
- i. Product assurance (includes quality, reliability, maintainability, safety, parts, materials, processes).
- j. Procurement.
- k. Schedules.

1.2 END ITEM SPECIFICATION - PART I, DESIGN REQUIREMENTS

The Principal Investigator is responsible for generating this document with support from the Payload Prime Contractor as required and directed by the Project Office. It is to be reviewed at the instrument PRR for NASA concurrence.

The document objectives are as follows:

- a. To specify in detail the functional performance goals and requirements on the instrument hardware in order to meet its mission objectives.
- b. To specify design requirements stemming from interface considerations (e.g. data formats, power, mechanical, location, specific environments, etc.) from safety considerations (e.g. design safety factors, redundancy, fail safe design, ejection mechanism, etc.) and from operational considerations (e.g. controls and display, access and field of view, EMI compatibility, prelaunch and in-orbit automated checkout, etc.).
- c. To specify verification requirements for qualification and flight acceptance. This will include designation of those requirements that must be verified by test rather than assessment of data.

The format to be used for this document is given in Appendix A of this document. Program guidelines are given in Sections 3 and 4 of this document.

1.3 END ITEM SPECIFICATION - PART II, DESIGN CONFIGURATION

The Instrument Developer (who may or may not also be the PI) is responsible for generating this document. He will be supported by the payload prime contractor as required and directed by the GSFC Project Office. The document will be presented at the instrument Preliminary Design Review (PDR) for NASA concurrence.

The document objectives are as follows:

- a. To define the instrument design configuration generated in response to the EIS-Part I requirements.
- b. To define the detailed verification/test plan to demonstrate compliance.

The format to be used is given in Appendix B of this document.

1.4 INSTRUMENT INTERFACE CONTROL DOCUMENT

The payload prime contractor is responsible for generating this document. The preliminary draft will be presented at the instrument PRR for NASA concurrence and it will be updated and maintained for each of the formal reviews as the instrument design evolves.

The objectives of the document are as follows:

- a. To define all interfaces of the instrument with program elements including ground support equipment, flight support equipment, Spacelab equipment, and the Orbiter.
- b. To specify the physical, functional, and operational constraints associated with each of these interfaces to satisfy ground

handling, prelaunch, launch, orbital operations, re-entry and landing activities.

- c. To define the operational induced environments to be anticipated at the instrument specific location.

This document will contain the results and conclusions of systems integration and compatibility analyses performed by the payload prime contractor. These efforts will require intensive interaction with the PI during the instrument definition phase (prior to PRR) and with the Instrument Developer after PRR until payload integration has been completed.

The guidelines and format for the ICD are given in the "AMPS to Instruments General Interface Document."

2. APPLICABLE DOCUMENTS

2.1 NASA

<u>NUMBER</u>	<u>TITLE</u>
NHB 8030.6 July 1974	Guidelines for Acquisition of Investigations
NHB 5600.2 February 1975	Statements of Work Handbook
NHB 5300.4 (1D-1) August 1974	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program
(No Number) NASA Headquarters Office of Space Flight June 1976	Safety Policy and Requirements for Payloads Using the Space Transportation System
JSC 11123 July 1976	Space Transportation System Payload Safety Guidelines Handbook

2.2 MILITARY

<u>NUMBER</u>	<u>TITLE</u>
MIL-STD-100B	Engineering Drawing Practices
MIL-D-5480E June 1970	Reproduction Requirements for Engineering and Technical Data

2.3 EUROPEAN SPACE AGENCY

<u>NUMBER</u>	<u>TITLE</u>
ESA SLP/2104	Spacelab Payload Accommodations Handbook

3. PROGRAMMATIC REQUIREMENTS GUIDELINE

3.1 INSTRUMENT CRITICALITY RANKING

The criticality ranking of an instrument is to be used as a guide to determine the appropriate levels of configuration management controls, product assurance and documentation to be imposed on the instrument development.

The original criticality ranking will be determined by the GSFC Project Office based on a joint recommendation by the PI (or Science Team Leader), the cognizant GSFC Technical Officer and the payload prime contractor. The rationale for the ranking will be presented for concurrence at the PRR and will be reverified at each subsequent review based on the current "Failure Mode Effects Analysis."

For instrument systems with functionally separable subsystems, each subsystem can be separately ranked if this permits a lower ranking for portions of the hardware.

The criticality rankings do not address scientific priority values.

The criticality categories definitions are given below in descending order of criticality.

Category I - Instruments with credible failure modes that could adversely affect crew safety.

Category II - Instruments with estimated development costs in excess of two million dollars or instruments that provide an essential performance element in an integrated complementary set of measurements

where the aggregate instrument costs are in excess of five million dollars.

Category III - Instruments not in Category I or II that require significant development or verification to produce flight-qualified hardware.

Category IV - Instruments of existing flight qualified design requiring nothing more than minor design adaptations and delta testing to produce flight qualified hardware.

3.2 GENERAL GUIDELINES

3.2.1 FLIGHT HARDWARE DELIVERABLE ITEMS

The SOW will specify the number of deliverable items of flight hardware. In general only one item of flight quality hardware will be fabricated. This unit will serve as a flight qualification test unit, and will be refurbished for flight acceptance. Qualification test levels of 1.5 times the anticipated flight levels are to be used with exposure times equivalent to that anticipated for a single flight. For instances where the instrument usage on multiple flights is anticipated, refurbishment and recertification inspections will be made as required.

3.2.2 REPAIRS

In general repairs will be made by replacement at the individual piece part level rather than at the sub-assembly or black box level.

Design and fabrication techniques should be utilized which facilitate this approach where possible. Where exceptions are deemed advisable they should be clearly justified and identified for spares provisioning analysis. See paragraph 3.3.9.3.

3.2.3 FORMAL DESIGN REVIEWS

Category I and II instruments will be subjected to the full sequence of formal design reviews:

Preliminary Requirements Review	(PRR)
Preliminary Design Review	(PDR)
Critical Design Review	(GDR)
Acceptance Review	(AR)

For Category III and IV instruments where deemed appropriate by the GSFC Project Office certain of these reviews may be scaled down to approval by the GSFC technical officer and the prime contractor representative to insure interface compatibility.

3.2.4 FAILURE MODES AND EFFECTS ANALYSES

FMEA's (See paragraph 3.3.6.1) will be required on every item of flight hardware with update for each formal review (or equivalent - see 3.2.3).

3.2.5 OPERATING, MAINTENANCE AND HANDLING PROCEDURES

Due to the nature of the Labcraft Program and the possibility for re-use of instruments on later flights, these procedures will be required on all items of flight instrumentation as part of the delivery package (See paragraph 3.3.8).

3.2.6 EIS-PART I AND PART II

For Category I and II instruments the instrument contractor will be required to develop the EIS-Part II to document the design configuration. For Categories III and IV the GSFC Project Office may elect to require only Part I to be supplemented by manufacturing drawings and test data. See paragraphs 3.3.3.1 and 3.3.3.2.

3.2.7 USE OF GSFC PREFERRED PARTS LIST

Use of the GSFC PPL will be required for Category I and II instruments, and discretionary to the instrument developer for Categories III and IV. See paragraph 3.3.6.2.

3.2.8 MATERIALS USAGE

Identification of materials, quantities and mode of usage will be required on all flight instruments in support of safety and contamination analyses. See paragraph 3.3.6.2.

3.2.9 THERMAL MODELS

The instrument developer will be required to generate a thermal model for the instrument which is compatible with the thermal model utilized by the prime contractor. The intent is to incorporate the instrument model into the payload level model for integrated systems analysis of the thermal environments.

3.2.10 VERIFICATION TESTING

The goal for verification test planning shall be to make maximum utilization of the instrument certification test facilities at GSFC. The objectives are to avoid duplication of such facilities and to assure the uniform interpretation and application of testing guidelines and criteria. However, where analysis indicates significant cost or schedule benefits from performing testing at other locations it should be so planned. See paragraph 3.3.7.1.

3.2.11 CONFIGURATION CONTROL

The level of configuration control appropriate to the specific instrument will be specified in the SOW. The specification baseline (EIS-Part I, paragraph 3.3.3.1) will be established at the Preliminary Requirements Review, and the configuration baseline (EIS-Part II, paragraph 3.3.3.2) at the Preliminary Design Review. See paragraph 3.2.3.

Subsequent changes to these baselines will be made by means of Engineering Change Proposals (paragraph 3.3.3.3) and Specification Change Notices (paragraph 3.3.3.4).

3.3 DOCUMENTATION

3.3.1 DOCUMENT TYPES

The documents to be provided by the Principal Investigator or the Instrument Developer will be identified in the SOW as falling into one of the following categories:

Type I - Those documents that shall be submitted for approval. With the exception of Engineering Change Proposals, implementation of these documents, and any changes thereto, shall not proceed until after (1) approval or (2) 14 days after receipt of document if no notice has been received that the document is disapproved or that implementation of the document shall be delayed. Engineering Change Proposals are Type I documents, but implementation shall not proceed until approval is received. Each Type I document shall be clearly marked prior to submittal with PRELIMINARY-NASA APPROVAL PENDING or APPROVED BY NASA - REFERENCE ----- as appropriate. Approved documents shall be submitted for use within seven days after receipt of approval.

Type II - Those documents that shall be submitted for review. Implementation of these documents may proceed without formal approval, but implementation shall not proceed prior to submittal of the documents. Implementation of subsequent changes to these documents shall not pro-

ceed prior to submittal of the changes. Each Type II document shall be clearly marked PRELIMINARY until ready for submittal.

Type III - Those required documents that are not submitted but shall be retained and made available upon request.

The SOW will also contain a table listing each of the documents to be provided, its type designation and a schedule for document submittal referenced to development program milestones.

3.3.2 MANAGEMENT PLAN

The SOW shall clearly specify the level of detail to be developed in the Management Plan for the specific instrument development. The purpose of the plan is to define the management organization and procedures to be used during the development of the instrument hardware. The plan shall address each of the following areas to an appropriate level of detail.

- a. General management structure, controls, and identify responsible individuals.
- b. Product Assurance - including safety, reliability (parts, materials, processes, procurement), and quality assurance.
- c. Configuration Management - provision shall be made to identify the configuration baseline, and to control changes to the baseline. This section shall also define the formal design reviews to be conducted during the course of the instrument development.
- d. Verification - including tests required, verification by other

means, verification to be performed by GSFC, etc.

- e. Logistics - includes spares provision and continuing maintenance support requirements.
- f. Manufacturing -
- g. Contamination Control - including all phases of instrument manufacturing, assembly, test, shipment and integration.
- h. Schedules -

3.3.3 CONFIGURATION MANAGEMENT DOCUMENTATION

The SOW shall specify the documents from the following list that are to be provided by the PI and instrument developer.

3.3.3.1 END ITEM SPECIFICATION PART I

The objectives of this document are as defined in paragraph 1.2, and the format guide is shown in Appendix A.

3.3.3.2 END ITEM SPECIFICATION PART II

The objectives of this document are as defined in paragraph 1.3 and the format guide is shown in Appendix B.

3.3.3.3 ENGINEERING CHANGE PROPOSALS (ECP)

An ECP shall be prepared for each change (including deviations and/or waivers) to the approved baseline configuration and requires approval prior to implementation. The ECP shall contain sufficient detail in the form of engineering information and other data to permit evaluation and approval or disapproval of the change. The requirement to prepare ECP's shall not be interpreted to restrict the desirability of preliminary informal interchange of information to explore and evaluate the engineering feasibility of desirability of changes.

3.3.3.4 SPECIFICATION CHANGE NOTICES (SCN)

An SCN shall be used to record exact changes to an approved specification and requires approval prior to implementation. A proposed change to a specification shall be submitted as a Preliminary Specification Change Notice (PSCN) attached to Engineering Change Proposal (ECP) and only after approval of the PSCN shall a final SCN be issued for implementation. The requirement to submit PSCN's shall not be interpreted to restrict the desirability of preliminary informal interchange of information to explore and evaluate the desirability of specification changes.

The SCN pages will be inserted in the affected specification opposite the applicable pages of the specification.

3.3.4 ENGINEERING DRAWINGS

Engineering drawings shall be prepared to control, by means of pictorial or narrative presentations or combinations thereof, the physical and functional engineering requirements for each part of the experiment hardware to be produced. The drawings shall be prepared in a tree that progresses from the top assembly drawing to detail component and part drawings. They shall provide directly, or by reference, all data needed for use in conjunction with other technical data such as reliability goals, test plans, test procedures, test reports, specifications, inspection procedures, acceptance and rejection criteria, processes, manuals, operational procedures, safety precautions, surface cleanliness requirements, etc. When specifications, standards, or other documents are referenced on the drawing and are peculiar to the organization preparing the drawings, copies shall be furnished with the drawings. Drawings included in Part I of the End-Item Specification shall not be changed after the Preliminary Design Review except by approval of Engineering Change Proposals/Specification Change Notices, see paragraphs 3.3.3.3 and 3.3.3.4. Drawings which are incorporated into Part II of the End-Item Specification shall not be changed after Critical Design Review except as specified in paragraphs 3.3.3.3 and 3.3.3.4.

3.3.4.1 GENERAL REQUIREMENTS

Engineering drawings shall include:

- a. All essential drawing information needed to permit an evalua-

tion or a feasibility study of the proposed design, or to document the results of exploratory research or development effort.

- b. Sufficient detail to enable evaluation and control of physical and functional design inter-relationships of interdependent components, equipments, subsystems, systems, ground support equipment, or facilities.
- c. All drawing information necessary to support installation, operation, maintenance, and interchangeability during tests and operational use.
- d. The necessary design, engineering, manufacturing, and quality support information directly or by reference to enable the procurement, without additional design effort or recourse to the original design activity, of an item that duplicates the physical and performance characteristics of the original design.

3.3.4.2 STANDARDS

Engineering drawings shall be prepared to the normal drafting standards of the organization and shall meet the following requirements:

- a. The numbering and coding of the drawings, associated lists and documents and revisions to the drawings shall comply with Section 3 and Section 5, Chapter 1 of MIL-STD-100.
- b. They shall be of sufficient clarity so that when reproduced, the reproductions shall meet the legibility requirements of MIL-D-5480.

- c. When symbols, referenced designations, codes, standards, abbreviations, etc., peculiar to the organization preparing the drawings, are referenced on the drawings they shall, if a Government or nationally recognized industry standard is applicable, include a cross reference to the Government or industry standard on the drawing or in a document furnished with the drawing. If a Government or nationally recognized industry standard is not applicable, the symbols, referenced designations, etc., shall be explained on the drawing or in a document referenced on the drawing.
- d. Drawings shall not be prepared or submitted when a Government or nationally recognized industry association specification or standard satisfies the requirement.
- e. For altered or selected items, drawings shall delineate complete details of the alterations, selections, or special requirements. These drawings shall include all information necessary to identify the item prior to its alteration or selection, including the original identifying part number and the name and address of the source of the original part.
- f. Applicable type, grade, class, or other classifications shall be shown on a drawing when a specification or standard is referenced.
- g. Special inspection and test requirements necessary to determine compliance with requirements for an item shall be defined on the drawing.

- h. When manufactured items (detailed parts, assemblies, etc.) are to be marked with part number identification, the drawings of such items shall specify the requirements, including the method of marking and the location of the part number.

3.3.4.3 TECHNICAL REPORTS

Technical reports shall document the results of studies and analyses performed during the development effort. The reports shall cover such areas as load analyses, stress analyses, trade-off studies, etc. Insofar as practical, these reports shall be submitted in the form in which they are prepared by the designer, design group, or other group performing the study. The internal documents of the organization (or contractor) shall be used to meet the requirements for technical reports.

3.3.4.4 REVIEW MINUTES

Minutes shall be prepared for each Preliminary Requirements Review, Preliminary Design Review, and Critical Design Review. The minutes for each review shall consist of two parts. Part A shall provide an immediate record of the review proceedings and shall include all items requiring post-review actions. Part B shall be prepared after the final disposition of each action item defined in Part A has been accomplished, and shall be a report of the final disposition.

3.3.4.5 CONFIGURATION INSPECTION (ACCEPTANCE REVIEW) REPORTS

A CI (Acceptance Review) report shall be prepared for each acceptance review. Each report shall provide a record of the review results including:

- a. Any action items with their disposition.
- b. Any deviations authorized.
- c. Any shortages authorized.
- d. Copy of the completed Material, Inspection, and Receiving Report, Form DD250.

3.3.5 QUALITY ASSURANCE DOCUMENTATION

3.3.5.1 ACCEPTANCE DATA PACKAGE

An acceptance data package shall be prepared for each deliverable end-item of experiment hardware. The package shall include but not necessarily be limited to the following:

- a. Equipment logs, see paragraph 3.3.5.2.
- b. Engineering drawings, see paragraph 3.3.4, down to the replaceable component level.
- c. Inventory of serialized components, which shall include:
 - (1) Component part number.
 - (2) Component name.
 - (3) Component serial number.
 - (4) Experiment hardware subsystem.

- d. Report of actual weight and center of gravity.
- e. Operating, maintenance, and handling procedures, see paragraph 3.3.8.
- f. Calibration data report, see paragraph 3.3.7.5.
- g. Part I and Part II of the End-Item Specification, see paragraphs 3.3.3.1 and 3.3.3.2.

Certification that the hardware has been cleaned in accordance with the Contamination Control Plan, paragraph 3.3.2(g).

Failure Reports, Failure Analysis Reports, and Correction Action Reports, see paragraphs 3.3.5.3, 3.3.5.4, and 3.3.5.5.

3.3.5.2 EQUIPMENT LOGS

The contractor shall prepare, maintain, and update the equipment record for each instrument as a means of documenting its continuing history. Each record shall be identifiable to the pertinent equipment and shall be maintained in chronological order to account for all fabrication, assembly, inspection, and test operations, as well as idle periods (storage) and movements of equipment. Entries shall be complete, self-explanatory, traceable to the individual and organization making the entry, and should include or refer to details such as the following:

- (1) Configuration data: parts list, drawings, specifications, changes, and identification data.
- (2) Fabrication and assembly history: buildup and disassembly instructions, repairs, rework, and modifications.

- (3) Inspection and test records: specifications, procedures, results, variables data.
- (4) Nonconformance summary: initial review and MRB actions, remedial and preventive actions, NASA approvals.
- (5) Cumulative operating times or cycles.
- (6) Maintenance records.

3.3.5.3 FAILURE REPORTS

Failure Reports shall contain the part number, name of part, serial number, part manufacturer, test being conducted when failure occurred, conditions at time of failure, description of failure, cause of failure, if known, and any other information considered pertinent.

3.3.5.4 FAILURE ANALYSIS REPORTS

Failure Analysis Reports shall be prepared for each Failure Report submitted in accordance with paragraph 3.3.5.3. A Failure Analysis Report shall reference the Failure Report, define the method of analysis, and document the results of the analysis.

3.3.5.5 CORRECTIVE ACTION REPORTS

Corrective Action Reports shall be prepared for each Failure Report submitted in accordance with paragraph 3.3.5.3. A Corrective Action

Report shall reference the Failure Report and the Failure Analysis Report. It shall define the action that will be taken to prevent recurrence of the failure, and if alternate solutions are possible, the justification for the selected action shall be included. If the corrective action necessary to prevent recurrence of the failure requires a change to the baseline configuration, a Corrective Action Report shall not be submitted but an Engineering Change Proposal shall be submitted in accordance with the requirements of paragraph 3.3.3.3. Corrective action reports shall indicate the need for reverification and shall contain provisions for signature closeout of the item.

3.3.6 RELIABILITY DOCUMENTATION

3.3.6.1 FAILURE MODE AND EFFECTS ANALYSES REPORT

A Failure Mode and Effects Analyses report shall be prepared in accord with paragraph ID301,3, (a&b) of NHB 5300.4(1D-1). This FMEA report will include a Critical Items List which identifies the single point failures or mission critical components.

3.3.6.2 APPROVED PARTS AND MATERIALS LIST

The instrument developer shall prepare and maintain a complete parts and materials usage list.

3.3.7 TEST DOCUMENTATION

3.3.7.1 TEST PLANS

The instrument developer shall prepare test plans that consolidate and integrate the test requirements contained in the end-item specification for the instrument. They shall differentiate between those test requirements that are to be satisfied by assessment methods or test and shall identify the documents that shall contain the assessment. For simple instruments test plans, test specifications, and test procedures may be combined into a single document.

Test plans shall define: specific tests to be conducted; equipment components, parts, etc., to be tested; objectives of the tests; locations where tests will be conducted; facilities and equipment support requirements; and the time phasing of the tests.

3.3.7.2 TEST SPECIFICATIONS

A test specification shall be prepared for each test identified in the test plan and shall be changed by submitting revised pages. Each test specification shall define the test objectives and performance criteria (with limits or tolerance), test item, number of items to be tested, environmental conditions, testing time or cycles, allowable maintenance, logging requirements, manner of analysis and utilization of test results, disposition of test specimens, and retest requirements.

For simple instruments test plans, test specifications, and test procedures may be combined into a single document.

3.3.7.3 TEST PROCEDURE

Test procedures shall be prepared for each test. The test procedures shall prescribe steps to be accomplished in detail and sequence, test equipment to be used, and calibration requirements, layout and interconnection of equipment, and safety practices (for equipment and personnel) to be observed.

3.3.7.4 TEST REPORTS

Test reports shall be prepared for each test identified in paragraph 3.3.7.1. The test report shall contain an evaluation of the test data, a comparison of test results with test objectives and design and performance requirements, and conclusions based on the evaluation.

3.3.7.5 CALIBRATION DATA REPORTS

A calibration data report shall be prepared for each deliverable set of instrument hardware and shall provide the actual calibration data sheets.

3.3.8 OPERATING, MAINTENANCE, AND HANDLING PROCEDURES

A document containing the operating, maintenance, and handling procedures shall be prepared for each end item of instrument hardware to define all procedures that will be required during the use of the end-item. The procedures shall contain all instructions for operating, servicing, maintenance, calibration, handling, cleaning, storage, packing, shipping, etc., as applicable. Any limited life or time critical items shall be identified and replacement cycles defined. The procedures shall include all diagrams, exploded views, sketches, text, etc., necessary to permit efficient performance of the required procedures. The procedures shall clearly indicate any step which, if not correctly followed, would result in serious injury to personnel and should give the reason for such warning.

The procedures for flight hardware shall be prepared in three volumes as follows:

Volume I - Subsystem Data:

This volume shall consist of two sections:

Section 1 - General Information - This section shall contain a general description of the structure and configuration of the flight hardware and shall describe the interfaces with other hardware and the flight vehicle as configured for the mission.

Section 2 - Instrument Subsystems - This section shall contain the following information for each subsystem.

- a. Subsystem schematics.

- b. A narrative description of the subsystem, its function, and how it affects and is affected by the other subsystems. The operational and design characteristics of the subsystem, component data, interface with other subsystems, and any system peculiarities shall be included. Performance data shall be limited to that necessary to support the functional descriptions, including operational limitations and restrictions as appropriate. The data shall be presented for both nominal and alternate modes of operation. The internal mechanics of the system shall be described only as necessary to insure that the reader fully appreciates what can be expected of the system.
- c. The subsystem operating limitations and restrictions shall be explained and why imposed. Methods of avoiding, and the consequences if limitations or restrictions are exceeded, shall be included.

Volume II - Mission Operational Procedures:

This volume shall consist of two sections - Normal Procedures and Contingency Procedures. The procedures shall be prepared in a step-by-step checklist format to include each discrete procedure as a separate operational item. Warnings, cautions, and notes shall be used in this volume to inform the crew against particular operational modes; that could result in performance degradation or affect flight safety.

Section 1 - Normal Procedures - This section shall contain normal operating procedures for conduct of the experiment including preparations for conducting the experiment, stowage between operations, main-

tenance required, stowage after completion of the experiment, etc.

The normal procedures are used if required subsystems are operating according to expectations. A remarks column shall be used to explain the rationale of the procedures and the operating constraints.

Each instrument, display, and control that is available to the flight crew shall be detailed as to its function, operational modes, range, accuracy, and inter-relationship with the instrument.

Section 2 - Contingency Procedures - This section shall contain the contingency procedures that will be used for at least partial accomplishment of experiment objectives when equipment or subsystem failures, or some other anomaly, prevent use of the normal procedures. A remarks column shall be used to explain the rationale of the procedures and the operating constraints.

Volume III - Ground Operating, Maintenance, and Handling Procedures:

This volume shall contain all necessary procedures to accomplish ground operations, maintenance, and handling of the flight hardware up to launch of the mission. For those portions of the flight hardware and/or experiment data to be returned to earth upon completion of the mission, the procedures to be followed during the recovery operations and after recovery shall be included.

3.3.9 INSTRUMENT HARDWARE SUPPORT REQUIREMENT

A document containing the instrument hardware support requirements shall be prepared to define the support required by the experiment PI.

It shall define all support required that is not defined by the instrument Interface Control Document. It shall include but not necessarily be limited to the following paragraphs.

3.3.9.1 FLIGHT CREW REQUIREMENTS

This section shall define any special flight crew training that must be accomplished to properly operate the instrument hardware, and any other required flight crew support which is not directly related to the flight hardware/flight crew interfaces. This section shall define the requirements for special training, such as study programs, simulation, etc., and shall define any procedures that must be performed by the flight crew prior to and after the mission to support the experiment requirements prior to, during, and after the mission.

3.3.9.2 DATA HANDLING AND REDUCTION REQUIREMENTS

This section shall define any special requirements for data handling and data reduction necessary to evaluate and analyze the experiment results. Any requirements for display or special handling of real-time data during the mission shall be included. Special support required in the handling of recovered items of flight hardware and physical data shall be included; however, the detailed procedures shall be included in the Operating, Maintenance, and Handling Procedures, see paragraph 3.3.8.

3.3.9.3 BASE SUPPORT REQUIREMENTS

This section shall define any special requirements for services, equipment, and facilities at off-site locations where logistics support is required as defined in the Management Plan, see paragraph 3.3.2.

These special requirements shall include such items as:

- a. Physical space.
- b. Security.
- c. Communications.
- d. Medical.
- e. Mail.
- f. Reproduction and graphics.
- g. Office machines, furniture, etc.
- h. Common supply items.
- i. Transportation and vehicle.
- j. Photographic.
- k. Tools and tool crib supplies.
- l. Shop services (machine, electrical, electronic, etc.).
- m. Calibration.
- n. Rigging.
- o. Materials testing, chemical analysis, X-ray, optical, etc.
- p. Safety.
- q. Utilities.
- r. Fuels, coolants, and gases.
- s. Ordnance storage and loading.

3.3.9.4 SPARES REQUIREMENTS

A document containing the spares requirements shall be prepared to define each spare necessary to support the instrument hardware. The document shall be sectioned in such a manner that the spares required are grouped by systems and subsystems and in next assembly order within the system and subsystems. The following information shall be included for each different spare:

- a. Part number.
- b. Name of part.
- c. Quantity required including those specified in Test Plans, paragraph 8.6.1.
- d. Required delivery dates.
- e. Planned use sites.

4. DESIGN REQUIREMENTS GUIDELINES

The design requirements which apply to a specific instrument stem from four source areas:

- a. Functional Performance - These are the fundamental performance requirements placed on the instrument to enable it to perform the planned experiment measurement or procedure. As such, these design requirements are uniquely derived for each specific instrument, and are not amenable to formulation of general guidelines.
- b. Operational Considerations - These design requirements are imposed by the constraints of prelaunch checkout and preparation, crew capabilities, interactions with other equipment, natural environments, etc.
- c. Safety - Safety considerations are a major source of requirements impacting instrument design. Examples are restrictions on the use of certain toxic materials, use of shatterable exposed elements, requirements to round edges, etc.
- d. Interface Constraints - Since the Orbiter, Spacelab and many elements of Flight Support Equipment are pre-existing items of hardware at the time instrument designs are in development phases, constraints on the instrument to payload interface are a source of requirement impacting the instrument design. Examples are data formats, electrical connectors, induced environment, etc.

The following paragraphs will develop guidelines in each of these areas as they are known to exist.

4.1 FUNCTIONAL PERFORMANCE GUIDELINES

4.1.1 FOLLOW-ON USAGE REQUIREMENTS

Due to the nature of Shuttle sortie mode payloads where the instruments are returned and are available for re-use on later flights, the follow-on usages of the instrument should be analyzed for potential effect on design requirements. The objective is to produce an instrument which preserves the option of being economically modified or upgraded in performance.

4.2 OPERATIONAL CONSIDERATIONS

4.2.1 INTERFACE VERIFICATION

Due to the limited access to the payload during many phases of pre-launch operations, instruments should be capable of complete electrical and data interface verification without access to the instrument. Where instruments must be maintained in a stowed or in-operative configuration, stimuli response simulation circuits should be incorporated to permit rapid and thorough checkout of the payload.

4.2.2 SELF CALIBRATION

Because of the limited time available for payload checkout, and the potential reflight of instrument in varying payload configurations, the instruments should incorporate internal self calibration for as many of the active elements in a measurement train as is feasible. Ideally this would consist of a known input to the primary entrance aperture or input detector. Where this end-to-end check is not feasible, known inputs should be injected at appropriate points to provide response data on as much of the instrument as possible. These calibration data should be incorporated into the data formats to permit automated processing.

4.2.3 REFURBISHMENT COMPATIBILITY

Flight instruments are to be designed such that any components requiring replacement, cleaning or other maintenance operations in order to prepare an instrument for reflight are readily accessible by normal disassembly of the unit.

4.2.4 PRE-LAUNCH PREPARATION

Instruments should be designed to reduce to a minimum requirements for late installation of time or environment sensitive elements (e.g., film, cryogenics, detectors, filters, etc). Where these requirements

cannot be eliminated the instrument should be designed to make the operation as simple and straight-forward as possible. The required procedures should be coordinated with the payload prime contractor to make sure that the required operations are feasible and have been included in the payload preparations planning. .

4.2.5 OPERATIONAL NATURAL ENVIRONMENTS COMPATIBILITY

The instrument should be designed for compatibility with the natural environments present at the altitudes and for the duration of the planned missions. This includes pressures, solar flux, and energetic particle flux.

4.2.6 POST LANDING OPERATIONS COMPATIBILITY

Requirements for early access to the instrument after landing in order to secure the instrument or for data retrieval are to be reduced to an absolute minimum. Any residual requirements are to be coordinated with the payload prime contractor to assure that they are considered feasible and have been included in the operation planning.

4.2.7 HERMETIC SEALING/VENT REQUIREMENTS

In order to avoid problems due to entrapped gases escaping over extended periods of time (relative to mission duration), any enclosed

volumes in the instrument are to be designed with one of two alternate approaches:

- a) Filtered vents such that pressure equilibrium is established between the inner volume and the ambient space environment within 10 hours after orbital altitude is reached, or
- b) The enclosed volume is to consist of a hermetically sealed structure adequate to withstand the pressure differentials due to the entrapped atmosphere. Leak rate at maximum anticipated differential pressure is to be less than (TBD) atmospheric milliliters per second.

4.2.8 ALIGNMENT

Instruments requiring precision alignment should provide optical reference surfaces to facilitate installation into the payload structure.

4.3 SAFETY CONSIDERATIONS

4.3.1 NASA HEADQUARTERS SAFETY REQUIREMENTS

All payload element, including instruments, shall comply with the requirements stated in the latest issue of the NASA Headquarters, Office of Space Flight document titled "Safety Policy and Requirements for Payloads Using the Space Transportation System."

4.3.2 STS SAFETY GUIDELINES

All instrument hardware is to be designed to the guidelines contained in the "Space Transportation System Payload Safety Guideline Handbook" (JSC-11123). This document is designed to comply with the payload safety requirements of the NASA Office of Space Flight. The guidelines are not to be construed as firm requirements, but rather as proven acceptable approaches to the resolution of safety concerns. Where these guidelines must be violated, the recommended design approach should be highlighted for specific consideration during formal technical reviews to assure that the alternate approach does not entail unacceptable safety risks. The document provides detailed guidelines in areas such as:

- a) Caution and Warning (Hazard Detection and Safing)
- b) Cryogenics
- c) Electrical
- d) Environmental Control
- e) Human Factor
- f) Hydraulics
- g) Materials
- h) Mechanical
- i) Optical
- j) Pressure Systems
- k) Propulsion
- l) Pyrotechnics

- m) Radiation
- n) Structures

4.3.3 SPACELAB SAFETY GUIDELINES

In addition to the detailed guidelines referenced in the preceding section (4.3.1), the instrument designs must comply with the requirements given in the most recent issue of the "Spacelab Payload Accommodation Handbook" (ESA REF NO SLP/2104).

4.4 INTERFACE CONSTRAINTS

Instrument design requirements necessary to provide interface compatibility will be derived from the "AMPS Payload to Instrument Interface Control Document." This is a program document which provides data, format and guidelines for the development of an instrument specific "Interface Control Document." See Paragraph 1.4. While the ICD is the responsibility of the payload prime contractor, the intent is to develop a negotiated, mutually acceptable interface between the instrument and payload that recognizes the needs and constraints of both sides of the interface. Many interface areas will require joint participation between the instrument developer and the payload prime contractor. Typical examples are discussed in the following paragraphs.

4.4.1 THERMAL ANALYSIS

The thermal functioning of each specific instrument is the integrated result of the interaction of a complex set of thermal relationships. The thermal model for the specific instrument must be incorporated into the payload thermal model maintained by the payload prime contractor in order to define the precise requirements to be levied on the instrument. This will define requirements for thermal coatings on exterior surfaces, thermal curtain interfaces, active versus passive systems, thermal standoffs, etc.

4.4.2 SOFTWARE

Instrument software requirements are to be coordinated with the payload prime contractor such that it can be incorporated into the mission software in an efficient manner.

4.4.3 HUMAN ENGINEERING OF CONTROLS AND DISPLAYS

Control and display needs of the instrument should be subjected to a systems analysis by the payload prime contractor to determine whether dedicated controls and displays are advisable versus use of a multifunction display capability afforded by the Spacelab equipment. An implicit part of this analysis is a human engineering analysis to optimize the crew interface with the operation of the instrument.

4.4.4 INTERFACE HARDWARE

Many areas of interface design can benefit from the use of standardized proven designs and design approaches. In areas where program economies can be effected by central procurement, the payload prime contractor will supply hardware items of an interface nature. Examples are given below.

- a) Electrical connectors
- b) Fluid line connectors
- c) Pallet hardpoint attachment fixtures
- d) Bonding straps
- e) Thermal curtain interface clamps
- f) Attachment mechanisms for deployable packages requiring unstow/restow operations in orbit
- g) Jettison mechanisms
- h) Pyrotechnic initiators and devices
- i) RF data link systems for deployed instruments
- j) Remote manipulator interface hardware
- k) Stub masts and booms

These items fall under the category of Flight Support Equipment.

APPENDIX "A"

1. INTRODUCTION

This appendix contains the recommended format and instructions for the preparation of "End Item Specification - Part I, Design Requirements" which are to be used in the definition and procurement of instruments for the Shuttle Spacelab Payload Project of Goddard Space Flight Center. It is intended for the guidance of principal investigators - or others with an equivalent level of responsibility - in preparing the subject specifications.

2.0 DEFINITION

The primary function of this document is to completely describe the requirements on the design of a specific item of instrument hardware intended for usage in space. These design requirements are the result of a summation and reconciliation of constraints stemming from four basic source areas:

- a. The performance goals to enable the instrument to meet its mission objectives;
- b. Operational considerations;
- c. Safety considerations;
- d. Interface compatibility

Some general guidelines in each of these areas are given in Paragraphs 4.1, 4.2, 4.3, and 4.4 of the Instrument Systems General Specification.

Additional functions of the document are:

- a. To identify any other documents (specifications, standards, etc.), which are applicable to the instrument development and to clearly qualify how they are to apply;
- b. To specify the verification requirements and methods to be used to assure compliance with the specification requirements;
- c. Delivery requirements such as packaging and method of shipment to be used.

3.0 FORMAT

3.1 COVER PAGE

A cover page containing the heading, specification title, instrument designation and the words "Goddard Space Flight Center, Greenbelt, Maryland," shall be used on all specifications. The heading shall include an identification number assigned by the GSFC/SSPP Office, a revision number and date of revision effectivity. The cover is to be printed on cover weight stock. An example of the layout is shown in Figure 1.

3.2 TITLE PAGE

The title page shall contain the identical information as the cover page with the addition of an approval signatures block as shown in Figure 2.

3.3 FOREWORD

A foreword page shall follow the title page. It shall contain the authorizing contract number, and shall identify the related documents for the specific instrument. These documents are:

Statement of Work

Experiment Requirements Document

Interface Control Document

GSFC Spec. No. _____

Revision _____

Date _____

END ITEM SPECIFICATION

PART I - DESIGN REQUIREMENTS

FOR

(INSERT INSTRUMENT TITLE)

(Insert Approval Signature Block in This
Space on Title Page Only)

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Figure 1 Sample Cover Page

PREPARED BY (Signature) DATE _____
Principal Investigator

APPROVED BY: (Signature) DATE _____
GSFC Project Manager

(Signature) DATE _____
PRR Review Board Chairman

CONCURRENCE: (Signature) DATE _____
Payload Prime Contractor
Systems Engineering Manager

Figure 2 Signature Block, Title Page

3.4 TABLE OF CONTENTS

A table of contents shall follow the Foreword. It shall list headings down to the third numeral level and shall include separate listings for illustrations, and tables.

3.5 SCOPE (SECTION 1)

This section shall describe briefly the item covered by the specification and indicate its principal purpose. Do not include here any details of construction, components, test, etc. In many cases a single sentence suffices; for example:

1. SCOPE

This specification describes requirements for the development of a laser sounder system to be used for remote measurements of the earth's upper atmosphere. The instrument will operate from the space Shuttle payload bay while in earth orbit at altitudes up to 200 kilometers.

This section should state the criticality category of the instrument in accordance with Paragraph 3.1 of the Instrument Systems General Specification.

3.6 APPLICABLE DOCUMENTS (SECTION 2)

This section shall list all drawings, specifications, data lists, and other applicable documents referred to in the specification.

Material of the referenced documents should not be repeated in the specification. List each document by title and number under headings for the various types, and provide a paragraph number reference to identify where the document applicability is defined. Specify the specific issue of the document which is applicable to the specification.

3.7 REQUIREMENTS (SECTION 3)

This section of the specification should state all the requirements for work to be done and items to be furnished under the contract. Performance requirements with tolerances, configuration requirements, as well as design studies and development tests should all be given here. Reference should be made to all necessary drawings, specifications, and other technical documents required for carrying out the work. Detailed descriptions should be given as necessary to define the subject of the specification. Typical material covered in REQUIREMENTS of the specification are described in the following paragraphs.

3.7.1 GENERAL DESCRIPTION

Before giving any details of construction, arrangement, subsystems, or components, an overall description should be given, indicating the general nature of the instrument, its size, shape, and main functions. This description, preceding the more detailed requirements, is of the greatest value in clarifying the concept of the instrument.

3.7.2 CONFIGURATION

Under the heading Configuration, the overall geometry and arrangement of the major subsystems should be given, including principal functions by name only.

3.7.3 DESIGN STUDIES

When required, design studies may be preliminary tests, study of technical data, mathematical and physical analyses, and any pertinent research and testing needed to serve as a basis for design of the instrument, and its various subsystems, or components. Include, also, any requirements for submission of preliminary designs, drawings, diagrams, calculations, alternative proposals etc.

3.7.4 STRUCTURAL REQUIREMENTS

This paragraph should be stated in as much detail as necessary to ensure compatibility with the vehicle or other related systems, and to provide the necessary space, strength, mass distribution, stability, etc., for carrying out the intended mission. Structural requirements ordinarily include such matters as weights, strengths, moments of inertia, alignment, centers-of-gravity, balance, materials for various parts, fabrication procedures, and access covers. These should be covered in detail under separate subparagraph headings. When feasible, data on weights, dimensions, tolerances, etc., should be given in tabular form. References should be made to applicable Federal or military specifications for test methods, materials, parts

(fasteners, etc.), and processes (welding, anodizing, etc.), as well as to available structural subsystem specifications.

Although resistance to certain mechanical environmental conditions (shock, acceleration vibration, sound) is related to structures, it is included with other environmental requirements under Paragraph 3.7.13.

3.7.5 ELECTRICAL AND ELECTRONIC REQUIREMENTS

This paragraph should state requirements for items such as motors, solenoids, wiring, switches, and transformers, where these are used in connection with power supplies, drivers, etc. In many cases, however, some of these items are more properly included with electronic equipment. Separate subparagraphs with appropriate headings should be written to cover the various components or parts.

Among the subjects to be covered under electronic requirements are communications, tracking, telemetry data processing and recording, storage, display, antennas, multiplexing and commands. An overall description of each subsystem should be given, followed by detailed requirements. The tests required to determine compliance with the performance requirements, tolerances, operational stability, etc., should be referred to. Reference should be made to any separate specifications for checkout of receivers, computers, inverters, command systems, etc.

3.7.6 OTHER REQUIREMENTS

The preceding sections are to serve as examples for any additional

sections needed to describe a specific instrument. This could include such areas as Optical Requirements, Fluid Systems Requirements, Ejection System Requirements, etc.

3.7.7 DEVICES

Devices commercially available can be specified in terms of available Government specifications or standards; or by reference to industry standards, data, ratings, and environments properties, when these indicate suitability for the purpose.

Requirements for calibration methods, operating ranges, and tolerances should be included, as well as compatibility with the specified telemetry systems, locations, and orientations.

3.7.8 CONTROLS AND DISPLAY REQUIREMENTS

The various types of control and displays required for efficient crew operations and caution and warning requirements are to be specified under separate subparagraph headings with information on ranges, accuracy, and functions included.

3.7.9 MODELS IN ADDITION TO FLIGHT MODEL

During the course of a development, the testing or submission of various types of equipment models may be required. In some cases these may be of the "breadboard" type, merely to check the operational feasibility

of a proposed electronic circuit, without regard to its later configuration or space requirements. Requirements for submission of such models for qualification tests or of test reports on their operation should be clearly indicated.

3.7.10 RELIABILITY AND REDUNDANCY REQUIREMENTS

Any require special studies, tests, or requirements to ensure reliability of various components of the system should be specified. These may include theoretical analyses of failure rates, accelerated tests, or use of parts which have been qualified as meeting reliability requirements of applicable specifications. Any of the instrument functions which require redundant paths to provide adequate reliability shall be designed such that an event which damages one path is not likely to affect the other. The design shall include the capability to verify satisfactory operation of each separate path during instrument checkout.

3.7.11 CLEANLINESS REQUIREMENTS

Instrument hardware shall be designed, manufactured, assembled, and handled in a manner to ensure the highest practical level of cleanliness. The greatest practicable precaution shall be taken to assure freedom from debris within the experiment hardware and inaccessible areas where debris and foreign material can become lodged, trapped, or hidden shall

be avoided. Protective covers shall be provided to prevent entrance of debris into inaccessible areas, or access panels shall be provided for removal of debris from these areas. Where appropriate, these protective covers may be designed for ground operations only and may be removed for flight.

3.7.12 TEST PROVISIONS

Flight hardware containing electrical and fluid systems shall include test points that will permit planned tests to be made without disconnecting tubing or electrical connectors that are normally connected in flight.

Test equipment shall be designed so that failure within the equipment or interruption of power will not cause failure or damage to instrument hardware being tested, and failure of the hardware being tested will not cause failure or damage to the test equipment.

3.7.13 ENVIRONMENTAL REQUIREMENTS

Environments as related to space instruments include conditions such as extreme temperatures, solar and cosmic radiation, reentry heating and ionization, acceleration, shock, weightlessness, vibration, extreme vacuum, or high pressures. Reference may be made to appropriate GSFC environmental test specifications, or new requirements may be written. In all cases the particular test conditions, including duration, should be specified.

3.7.14 INSPECTION REQUIREMENT

This will include any specific on-the-job inspection required to determine whether specified plant procedures, cleanliness, and proper care in fabrication and assembly are being exercised, Inspection may also include specific checking of dimensions, fits, and similar measurements to assure compatibility between various parts of the system, or of visual evaluation of workmanship, assembly, finish, tightness, soldering, etc.

3.8 VERIFICATION REQUIREMENT (SECTION 4)

This section shall establish the integrated verification requirements for the instrument hardware for each performance/design requirement stated in Section 4 of the document, and specify the method to be used for verification.

3.8.1 VERIFICATION MATRIX

The requirements and methods are to be developed into a matrix in accordance with the example given in Figure 3 as a tabular summary of the integrated verification requirements.

Nomenclature		Criticality Category		End Item No.						
Requirements for Verification										
TEST TYPES: A. - Development B. - Qualification C. - Reliability N/A - Not Applicable		VERIFICATION METHODS: 1. Test a. Functional b. Mechanical c. Electrical/Magnetic d. Environmental e. Materials Compatibility f. Life g. Off Limits h. Combined Tests i. Other Tests (specify) 2. Assessment a. Similarity b. Analysis c. Inspection d. Demonstration								
Section 3.0 Performance/Design Requirement Reference		Test Types/ Verification Methods							Section 4.0 Test/Assessment Requirement	
		A	B	C						
Each requirement from Section 3.0 shall be listed by paragraph number. 3.1.1 3.1.1.1 3.1.1.2 3.1.1.2.1 3.1.1.2.2 3.1.1.2.3 3.1.2 3.1.2.1			1a 1a 1b 1c 1h						X X	4.2.1.3 4.2.1.3 4.2.1.3.2 4.2.1.3.3 4.2.1.3.7 A paragraph number from Section 4.0 to indicate how each requirement listed from Section 3.0 will be verified, shall be listed here.
Prepared by:			Org.		Date		Rev. Date		Rev. No.	
Approved by:			Org.		Date		Page			

Figure 3 Typical Verification Matrix

3.8.2 VERIFICATION TYPES AND METHODS

This section shall identify the types of verification required for the specific instrument, the methods to be used and the levels and duration of the tests.

3.8.2.1 DEVELOPMENT TYPE

Development tests are performed to acquire data to support the design and development process, to verify feasibility of the design approach by evaluating hardware performance under simulated or actual environmental conditions, and to verify selected performance/design requirements. These tests shall be performed on hardware that is representative of, but not necessarily identical to, the flight hardware. Each requirement of Section 3.0 that is to be verified by development tests shall be specified in an appropriate subparagraph.

3.8.2.2 QUALIFICATION TYPE

Qualification tests, including verification methods, are performed to verify the performance/design/construction requirements of the end-item. Qualification shall be performed on hardware produced using the same materials and processes, under the same conditions as those intended for flight hardware, and which is the same configuration as flight hardware. Each requirement of Section 3.0 that is to be verified by qualification tests shall be specified in an appropriate

subparagraph identifying the applicable verification method, test levels and durations.

For these instruments where only one item of flight type hardware is to be fabricated, the qualification verification will be performed on this unit.

3.8.2.3 RELIABILITY TEST

Reliability Tests, when specifically approved by the GSFC may be performed to establish significant levels of engineering confidence for assuring crew safety or mission success. When required, they shall be conducted as an extension of the Development and Qualification Test program. The Integrated Test Program shall be planned to assure that the data can be utilized for reliability assessment. Each requirement of Section 3.0 that shall be verified by Reliability Tests shall be specified in an appropriate subparagraph along with the applicable verification method, test levels, durations and acceptance/rejection criteria.

3.9 PREPARATION FOR DELIVERY (SECTION 5)

This section should cover all requirements for the handling, protection, preservation, packaging, packing, marking, and transportation of any instrument item or subsystem.

3.9.1 PACKAGING

Requirements for packaging may include cleaning, drying, preservative methods, protective wrappings, and cushioning or special mounts. Reference may be made to one of the methods of Specification MIL-P-116, or the detailed methods may be written out. For some items, commercial packaging may be specified. One of the various "levels" may be specified, in accordance with Federal Standard 102--Preservation, Packaging, and Packing Levels.

3.9.2 PACKING FOR SHIPMENT

The type of box, crate, or special container should be specified. For many items in space projects, development includes the design of special containers with protective shock mounts and, in some cases, control of temperature and humidity. It is usually necessary for specification writers to secure the advice of specialists in this field to determine suitable procedures, materials, and devices. When explosives or other dangerous articles are involved, the Interstate Commerce Commission regulations given in Code of Federal Regulations, 49 CFR 71.1--Transportation must be strictly observed.

3.9.3 MARKING FOR SHIPMENT

Marking is fully covered in FED-STD-123--Marking for Domestic Shipment (Civilian Agencies), and should be followed in all cases.

Marking of both packages and shipping containers should identify completely the contents, including the name of the contractor or manufacturer, quantity or weight, contract or order number, etc.

3.9.4 HANDLING AND TRANSPORTATION

When any special type of handling transportation is required, this should be specified in detail. Special trailers, containers, shock and vibration resistant supports, and control of temperature and humidity may be required.

3.10 NOTES (SECTION 6)

Information on intended uses and other pertinent matters in connection with the specification are usually included here. Notes should never contain specification requirements. Data given in the NOTES section of the specification should normally not be identified as line items in the contract.

3.10.1 DEFINITIONS

Definitions are often given in the NOTES section, when terms peculiar to the agency or the particular items involved are used, or to make sure that the meanings are not misunderstood. In connection with space projects, many new or unfamiliar terms and meanings have come into wide use;

for example, reentry, thrust, specific impulse, electron density, electron temperature, sustainer, micrometeoroid, radiation belts, LH_2 , cloud cover, apogee, perihelion, parking orbit, inertial guidance, or ion propulsion. The use of the NASA Glossary of Aerospace Terminology promulgated by NASA Headquarters is encouraged..

3.10.2 SAFETY PRECAUTION

Any special safety precautions involved in the manufacture of the item or use of materials should be given here.

4.0 GENERAL REQUIREMENTS

Specifications should establish requirements, as far as practicable, in terms of performance to permit solicitation of competitive bids from the largest segment of industry. This practice results in the broadest base for competition, and thus the lowest cost to the Government. However, it is often necessary to include specific design details in specifications to minimize variances and to secure maximum reliability, interchangeability, and maintainability.

Specifications should be typed on standard-size paper (8-1/2 x 11 inches), single spaced with double spacing between paragraphs. Capital letters should be used only for titles, main headings, and proper names. Words such as "specifications," "standard," and "handbook," are not capitalized unless they are used in connection with a particular item, thus:

"as specified in Handbook H-28."

"shall be in accordance with Specification QQ-Z-325,
type III."

In general, typed specifications should conform as nearly as possible to the style specified in the Government Printing Office Style Manual. Standards particularly applicable to GSFC specifications are discussed in the following paragraphs.

4.1 MARGINS AND PAGE NUMBERS

Page numbers of typed copy should be at the bottom center of each page, not less than 1/2 inch above the bottom edge. When right- and

left-hand pages are used in final copy, the right-hand pages shall contain odd numbers, left-hand pages, even numbers.

Margins should be 1-1/4 inches on the left and at the top, and not less than 3/4 inch at the right and bottom (for text) except that the specification identification number (right-hand pages only) in the upper right-hand corner.

4.2 PARAGRAPH NUMBERING AND STRUCTURE

Each paragraph and subparagraph shall be numbered, using the decimal system. Both main paragraphs and subparagraphs should have headings indicating the subject matter. The word "general" should not be used as a paragraph heading.

Single sentence paragraphs or use of successive decimal numbers for each item in a listing should be avoided. Paragraph numbers in excess of four digits are seldom necessary and should be avoided. When a cross reference is made to a previous or subsequent paragraph, only the number need be given; e.g., "as specified in 3.1.1.1." In addition to proper numbering, it is also important that standard indentations be used to reflect paragraph weights and to emphasize the organization and paragraphs.

4.3 ABBREVIATIONS

Restrict abbreviations to those in common use whose meaning

is clear and unambiguous. Except for such widely used abbreviations as U. S., Yd. and lb., the abbreviation should, when first used, be placed in parentheses after the word(s) spelled out; for example, "The noise level shall not exceed 20 decibels (db)." Terms which seldom occur should, in general, not be abbreviated. Use of abbreviations may be used in tables and figures to save space. Note that the same abbreviation is used for both plural and singular, and periods are omitted unless there is a chance of confusion with other words.

4.4 SYMBOLS

Avoid the use of (') or (") for feet and inches. Dimensions should be given in the form 2 by 4 rather than 2 x 4. The percent symbol (%) should not be used in the text, but may be used in tables where space is limited. Chemical symbols should not be used in the text, but may be used in figures and tables where space is limited.

4.5 FOOTNOTES

Footnote references in the text should be used sparingly. When used, they are numbered consecutively within a page and are placed at the bottom of the page on which they appear. Footnotes to tables are numbered separately for each table; if numerals lead to ambiguity, superior letters, asterisks, daggers, and other symbols may be used. Footnotes or notes in the text shall not be used to specify mandatory

requirements. In tables, they may be used where necessary for mandatory requirements forming part of the table.

4.6 FIGURES

Drawings and figures can be used whenever practicable to describe an item more clearly and accurately than can be stated in the text. Illustrations and graphs which form a part of the specification should be included except when they form part of a referenced specification, standard, or publication available from other sources. Figures should appear in the body of the specification following the paragraph or page containing the first reference to the figure. However, if figures are numerous and interfere with the correct sequencing of paragraphs or cause difficulty in understanding or interpreting, the figures may be placed in numerical sequence at the end of the specification as an appendix.

Figures shall be numbered consecutively in Arabic numerals in the order in which they are first referenced in the specification. The caption, including the number and a fully explanatory title, is placed under each figure; all items of significance shown on the figure should be identified by callout.

4.7 TABLES

Tables should be used wherever possible to present data or requirements.

Tables shall be numbered consecutively in Roman numerals in the order in which they are initially referenced in the specification. Each table shall bear a caption at the top showing the number and a fully explanatory title. Tables are located following the paragraph in which the first reference appears, or placed on the succeeding page. However, if tables are numerous and this location would interfere with the correct sequencing of paragraphs or cause difficulty in interpretation, the tables may be placed in numerical sequence in an appendix at the end of the specification following the figures. Foldout pages should be avoided.

4.8 PROPRIETARY NOMENCLATURE

Avoid the use of proprietary names such as trade names, trademarks or other designations selected by companies for their equipment when they apply exclusively to the product of a particular company. If used, the name shall be preceded by "similar to," "interchangeable with," or similar wording which will permit competition in bidding. Reference should be made to Armed Services Procurement Regulation 1-1206 for specific requirements for use of this terminology. This instruction also applies to manufacturer's part numbers or drawing numbers of minor parts when it is impractical to specify the exact requirements. Do not use the term "or equal."

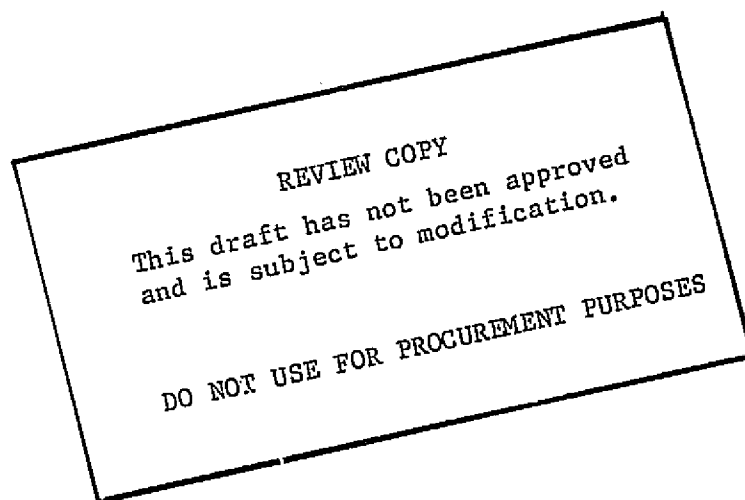
4.9 CONTRACTUAL AND ADMINISTRATIVE REQUIREMENTS

Specifications shall not include requirements which are properly included in the schedule of the contract, such as time of delivery,

method of payment liquidated damages, provisions for items damaged or destroyed in tests, progress reporting, and documentation (instruction manuals, final reports, etc.,).

4.10 REVIEW DRAFTS

When a specification draft is to be circulated for review comment or concurrence before approval, the following statement should be placed on the cover in the manner indicated.



APPENDIX "B"

1.0 INTRODUCTION

This appendix contains the recommended format and instructions for the preparation of "End Item Specification - Part II, Design Configuration". It is a follow-on document to the EIS-Part I treated in Appendix "A". These instructions are for the guidance of the Instrument Development Contractor in preparing the subject specification.

2.0 DEFINITION

The primary function of this document is to describe the design configuration baseline developed in response to the requirements defined in Part I of the EIS.

Additional functions of the document are:

- a. To identify any other documents - in addition to those already identified in Part I - which are applicable to the instrument development and to clearly qualify how they are to apply.
- b. To identify the specific parts, materials and processes to be used in the fabrication of the instrument.
- c. To define the detailed test procedures to complete the verification plan from Part I of the EIS.

3.0 FORMAT

3.1 COVER PAGE

The cover page shall be to the same general format as that for Part I. The heading in the upper right hand corner will use the same number assigned to Part I of the EIS but will carry revision number and effectivity dates unique to Part II. An example of the layout is shown in Figure I.

3.2 TITLE PAGE

As in Part I the title page is to be identical to the cover page but with the addition of the signatures block as shown in Figure 2.

3.3 FOREWORD

A Foreword page shall follow the title page. It shall contain the authorizing contract number, and shall identify related documents for the specific instrument. These documents are

Statement of Work

Experiment Requirements Document

Interface Control Document

End Item Specification - Part I

GSFC Spec. No. _____

Revision _____

Date _____

END ITEM SPECIFICATION

PART II - DESIGN CONFIGURATION

FOR

(INSERT SAME TITLE USED FOR PART I)

(Insert Approval Signature Block in This
Space on Title Page Only)

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Figure 1 Sample Cover Page

PREPARED BY: (Signature) DATE

Instrument Development
Program Manager

APPROVED BY: (Signature) DATE
Principal Investigator

(Signature) DATE
CDR, Chairman

(Signature) DATE
GSFC Project Manager

CONCURRENCE: (Signature) DATE
Payload Prime Contractor
Systems Engineering Manager

Figure 2 EIS-Part II Signature Block, Title Page

3.4 TABLE OF CONTENTS

A table of contents shall follow the Foreword. It shall list headings down to the third numeral level and shall include separate listings for illustrations, and tables. .

3.5 SCOPE (SECTION 1)

This section shall begin with the sentence: "This specification establishes the requirements for complete identification and acceptance of all units of (insert end-item number and nomenclature) to be formally accepted by the National Aeronautics and Space Administration. It specifies the performance, configuration, and manufacturing techniques that are necessary to reproduce the end-item and becomes the controlling document for acceptance of the end-item."

3.6 APPLICABLE DOCUMENTS (SECTION 2)

This section shall list only those specific documents (specifications, standards, drawings, bulletins, manuals, etc.) that are applicable to paragraphs within the body of the specification, and that are supplementary to the list in Part I of the EIS. Do not repeat documents already listed in Part I.

3.7 PRODUCT REQUIREMENTS (SECTION 3)

3.7.1 PERFORMANCE

Performance characteristics necessary for the complete identification of the instrument shall be specified in this paragraph. In cases where the performance characteristics are identified on the manufacturing drawings and specifications (paragraph 3.8.1), they need not be repeated in this paragraph.

3.7.2 FUNCTIONAL CHARACTERISTICS

Those characteristics that define the function of the instrument shall be identified herein. Typical functional parameters are cyclic rate, frequencies, modulation, input level, subcarrier channels. When the functional characteristics are included with the information provided in paragraph 3.8.1, they need not be repeated in this paragraph.

3.8 CONFIGURATION (SECTION 4)

This paragraph shall contain the top assembly drawing that depicts the relative locations of all major units of the hardware and will be the master control drawing for the manufacture and assembly of all parts necessary to provide a complete set of hardware to meet the

requirements of Section 3.0 of Part I of the End-Item Specification. It shall contain the part numbers of all subsystems and major assemblies that comprise the top assembly. If the inclusion of the top assembly drawing in this paragraph is impractical because of size, excessive amount of detail, etc., an arrangement drawing may be substituted that shall contain the top assembly drawing number and the part numbers of all subsystems and major assemblies that comprise the top assembly.

3.8.1 MANUFACTURING DRAWINGS

This paragraph shall contain or reference all necessary data to provide a complete description of the detail design to a level of detail necessary to establish the baseline configuration for manufacturing. Manufacturing drawings shall include the specifications and standards that are applicable to the manufacture of the instrument; Government furnished equipment used in the instrument shall be identified by part number, nomenclature and quantity.

Drawings shall comply with the requirements of paragraph 3.3.4 of the Instrument Systems General Specification.

3.9 PRODUCT ACCEPTANCE REQUIREMENTS (SECTION 5)

Acceptance tests, including verification methods, shall be performed to verify the performance and configuration of the

instrument hardware at the time of (1) its acceptance by the Government, or (2) delivery to another NASA Center.

Acceptance of instrument hardware shall be performed at the end-item level, whenever practical. Acceptance tests shall verify that the deliverable hardware is equivalent in performance and configuration to the previously qualified end-item. Each requirement of Section 3.0 of the EIS - Part I that is to be verified by acceptance tests shall be specified in appropriate subparagraphs below identifying the applicable verification method, and acceptance/rejection criteria.

3.9.1 ACCEPTANCE MATRIX

The instrument developer shall specify the assessment and/or test requirements for each performance/configuration requirement specified in Part II, Section 3.0 of the End-Item Specification. These requirements shall be developed into a verification matrix prepared in accordance with the format of Figure 3.

3.9.2 OTHER TESTS

The requirements for verifying performance and configuration for acceptance at locations other than the manufacturing facility shall be specified in this paragraph. The GSFC/Project Office shall approve the acceptance of instrument hardware at other locations and shall

Nomenclature	Criticality Category		End Item No.	
Requirements for Acceptance				
<u>TEST TYPES:</u> A. Acceptance N/A - Not Applicable		<u>VERIFICATION METHODS:</u> 1. Test a. Functional b. Mechanical c. Electrical/Magnetic d. Environmental e. Combined Tests f. Other Tests (specify)		
Section 3.0 Performance/Configuration Requirement Reference		Section 4.0 Test/Assessment Requirement		
		Test Types/ Verification Methods		
		A		N/A
Each requirement from Section 3.0 shall be listed by paragraph 3.0 3.1 3.1.1 3.1.2 3.2 3.2.1 3.2.2 3.2.3		1f 1f 2c 2d 2d 2d 2d	X	4.2.1.5 4.2.1.5 4.2.1.3 4.2.1.4 4.2.1.4 4.2.1.4 4.2.1.4
		A paragraph number from Section 3.0 to indicate how each requirement from Section 3.0 will be verified shall be listed here.		
Prepared by:		Org.	Date	Rev. Date
Approved by:		Org.	Date	Page

Figure 3 Typical Verification Matrix Example

assure that the test types are properly identified on the verification matrix of Figure 3.

3.10 DATA LIST (SECTION 6)

The instrument developer shall list reports, manuals, plans, and other data required during the development phase. The list shall be composed of documentation selected from Section 3.3 of the Instrument Systems General Specification.

3.11 PREPARATION FOR DELIVERY (SECTION 7)

3.11.1 PRESERVATION AND PACKAGING

The requirements for the cleaning, preservation, and packaging of experiment hardware for protection against corrosion, physical damage, and other forms of deterioration during handling, shipment, and storage shall be specified in this paragraph. The appropriate sections of MIL-P-116 shall be applicable to experiment hardware preservation and packaging requirements and methods.

Adequate structure and cushioning shall be employed to prevent damage from in-transit shock, vibration and externally applied loads. Whenever possible, equipment and packaging shall be designed to be transported and handled by common carrier without special handling

devices or environmental controls. The packaging of backup components shall be compatible with storage and servicing requirements of the end-item.

3.11.2 PACKING

The mode of transportation or shipment specified by the GSFC Project Office shall determine the packing required.

3.11.3 SHIPMENT

The mode of shipment shall be as specified by the GSFC Project Office.

Items that are subject to ignition/detonation by electro-static discharge, and that are to be packaged in bags or wraps manufactured from non-conductive plastic or plastic coated barrier materials, shall first be individually wrapped in a package of conductive material that has provisions for grounding during handling and shipping.

3.12 NOTES (SECTION 8)

This section shall not be contractually binding, but may be used for administrative information or information of interest to NASA relative to the usage of the subject instrument.

4.0 GENERAL REQUIREMENTS

The requirements of this section are identical to Section 4.0 of Appendix "A".